

WHAT IS CLAIMED IS:

1. A method of inspecting a defect in or on a semiconductor wafer, comprising:
directing a beam towards the surface of the semiconductor wafer wherein/whereon
the defect resides to thereby emit X-rays;
5 detecting the emitted X-rays with plurality of detectors positioned at a plurality of
angles with respect to the wafer surface;
collecting X-ray data from the detectors; and
using the X-ray data to spatially resolve the location of the defect with respect to the
semiconductor wafer.
- 10 2. A method as recited in claim 1, wherein the detectors detect the emitted X-rays
simultaneously.
- 3 A method as recited in claim 1, wherein using the X-ray data to spatially resolve the
location of the defect is accomplished by generating an image based on the X-ray data.
4. A method as recited in claim 3, wherein the image is generated by combining the X-
15 ray data from at least two X-ray emission energy spectra.
5. A method as recited in claim 1, wherein the defect resides fully within a sample
volume.
6. A method as recited in claim 1, wherein the beam is stepped over an area where the
defect resides.
- 20 7. A method as recited in claim 6, wherein the beam is stepped in a grid configuration.
8. A method as recited in claim 1, wherein the beam is rastered over an area where the
defect resides.
9. A method as recited in claim 1, wherein the directed beam is an electron beam.
10. A method as recited in claim 1, wherein the directed beam is a focused ion beam.

11. A method as recited in claim 1, wherein the elemental composition of the defect is determined from the X-ray data.

12. A method as recited in claim 1, wherein the semiconductor wafer comprises copper surrounded by dielectric material.

5 13. A method as recited in claim 12, wherein the detected X-rays are at least copper $K\alpha$ and copper $L\alpha$ X-rays.

14. A method as recited in claim 12, wherein the detected X-rays are at least copper $K\alpha$, copper $L\alpha$ and silicon $K\alpha$ X-rays.

15. A method of inspecting a defect in or on a semiconductor wafer, comprising:

10 directing a beam towards the surface of the semiconductor wafer wherein/whereon the defect resides to thereby emit X-rays;

detecting the emitted X-rays with a detector at a first angle with respect to the wafer surface;

collecting X-ray data from the detector;

15 directing a beam towards the surface of the semiconductor wafer wherein/whereon the defect resides to thereby emit X-rays;

detecting the emitted X-rays with the detector at a second angle with respect to the wafer surface;

collecting X-ray data from the detector; and

20 using the X-ray data to spatially resolve the location of the defect with respect to the semiconductor wafer.

16. A method as recited in claim 15, wherein the detectors detect the emitted X-rays at different sampling times.

25 17. A method as recited in claim 15, wherein the detector detects emitted X-rays at a plurality of angles with respect to the wafer surface.

18. A method as recited in claim 15, wherein the second angle of the detector with respect to the wafer surface is achieved by moving the position of the detector after collecting the X-ray data from the first angle.

19. A method as recited in claim 15, wherein the first angle of the detector with respect to the wafer surface is achieved by tilting the wafer after collecting the X-ray data from the first angle.

20. A method as recited in claim 15, wherein using the X-ray data to spatially resolve the location of the defect is accomplished by generating an image based on the X-ray data.

21. A method as recited in claim 22, wherein the image is generated by combining the X-ray data from at least two X-ray emission energy spectra.

22. A method as recited in claim 15, wherein the defect resides fully within a sample volume.

23. A method as recited in claim 15, wherein the beam is stepped over an area where the defect resides.

24. A method as recited in claim 23, wherein the beam is stepped in a grid configuration.

25. A method as recited in claim 15, wherein the beam is rastered over an area where the defect resides.

26. A method as recited in claim 15, wherein the directed beam is an electron beam.

27. A method as recited in claim 15, wherein the directed beam is a focused ion beam.

28. A method as recited in claim 15, wherein the elemental composition of the defect is determined from the X-ray data.

29. A method as recited in claim 15, wherein the semiconductor wafer comprises copper surrounded by dielectric material.

30. A method as recited in claim 29, wherein the detected X-rays are at least copper K α and copper L α X-rays.

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31. A method as recited in claim 29, wherein the detected X-rays are at least copper K α , copper L α and silicon K α X-rays.

32. A method of inspecting a defect in or on a semiconductor wafer, comprising:
directing a beam towards the surface of the semiconductor wafer wherein/whereon

5 the defect resides to thereby emit X-rays;

detecting the emitted X-rays at a plurality of angles with respect to the wafer surface
with one detector;

collecting X-ray data from the detector; and

using the X-ray data to spatially resolve the location of the defect with respect to the
10 semiconductor wafer.

33. A method as recited in claim 32, wherein the detector detects the emitted X-rays
simultaneously.

34. A method as recited in claim 32, wherein the detector detects emitted X-rays at a
plurality of angles with respect to the wafer surface.

15 35. A method as recited in claim 32, wherein using the X-ray data to spatially resolve the
location of the defect is accomplished by generating an image based on the X-ray data.

36. A method as recited in claim 35, wherein the image is generated by combining the X-
ray data from at least two X-ray emission energy spectra.

37. A method as recited in claim 32, wherein the defect resides fully within a sample
20 volume.

38. A method as recited in claim 32, wherein the beam is stepped over an area where the
defect resides.

39. A method as recited in claim 38, wherein the beam is stepped in a grid configuration.

40. A method as recited in claim 32, wherein the beam is rastered over an area where the
25 defect resides.

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41. A method as recited in claim 32, wherein the directed beam is an electron beam.

42. A method as recited in claim 30, wherein the directed beam is a focused ion beam.

43. A method as recited in claim 30, wherein the elemental composition of the defect is determined from the X-ray data.

5 44. A method as recited in claim 30, wherein the semiconductor wafer comprises copper surrounded by dielectric material.

45. A method as recited in claim 44, wherein the detected X-rays are at least copper $K\alpha$ and copper $L\alpha$ X-rays.

46. A method as recited in claim 44, wherein the detected X-rays are at least copper $K\alpha$,
10 copper $L\alpha$ and silicon $K\alpha$ X-rays.

47. An apparatus for inspecting a defect in or on a semiconductor wafer, comprising:
a beam generator operable to direct a charged particle beam towards a structure;
a plurality of detectors positioned at different angles with respect to the surface of the
semiconductor wafer to detect X-rays from the structure in response to the charged particle
15 beam; and

a processor operable to:

cause the beam generator to direct a beam towards the structure; and

characterize one or more defects based on the detected X-rays.

48. An apparatus as recited in claim 47, wherein the characterizing operation is based on
20 a ratio of a first X-ray intensity for a first material over a second X-ray intensity for a second
material, wherein the first and second X-ray intensities are obtained from the detected X-rays
from the scanned structure.

49. An apparatus as recited in claim 47, wherein the scanned structure is a portion of a
interconnect structure in an integrated circuit device.

25 50. An apparatus as recited in claim 47, wherein the directed beam is an electron beam.

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51. An apparatus as recited in claim 47, wherein the electron beam is stepped over an area of the sample surface.

52. An apparatus as recited in claim 47, wherein the electron beam is rastered over an area of the sample surface.

5 53. An apparatus as recited in claim 47, wherein the directed beam is a focused ion beam.